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Study of Sustainability Irigation System (Case study on Haliwen Small Dam Reservoir)

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ABSTRACT

One important indicator in the sustainability of irrigation systems is the reliability of irrigation buildings. Some important factors that can influence it are building operations, building maintenance, community participation, and the value of benefits. This article discusses how the influence of each of these factors on the reliability of irrigation buildings. This study was conducted at Haliwen small dam Reservoir in Atambua NTT. The approach used is structural equation modeling (SEM) with WarpPLS. The results of the analysis show that the variables of operation, maintenance and benefit values have a significant effect on the reliability of mall dam reservoir, while community participation does not directly influence the reliability of small Dam reservoir and the analysis also confirm that to obtain a good value of benefit is highly dependent on community participation in operations and maintenance.

Keywords: Sustainability, Irigation, Small Dam Reservior, Reliability

I. INTRODUCTION

The sustainability of irrigation systems in rural areas in NTT generally depends on the reliability of irrigation buildings such as small dam reservoir. Therefore, since 1980 in NTT small dam reservoir has been built. However, until now, various problems often occur and threaten their sustainability. Basically, operations and maintenance activities have been used as the main indicator in ensuring the sustainability of irrigation systems [1]

For this reason, it is necessary to evaluate the sustainability of irrigation from small dam reservoir in NTT. One indicator that affects the sustainability of irrigation systems is the reliability of irrigation buildings [2]. This is important because in many small dam reservoirs there is a decline in function and some do not function at all [3][4][5]. The decline in this function (damage) must be immediately addressed to prevent the failure of small dam reservoir structures so that irrigation systems do not meet the optimal and reduce the efficiency value of small dam reservoir[6]. Reliability of irrigation buildings has been assessed based on the damage, then given the weight and then determined the type of handling [7].

However, the reliability of buildings is measured not only by how much damage or function they have, but also how the benefits are and is heavily influenced by aspects of human resources, operations and maintenance. Therefore, the factors that have a significant impact on the reliability of an irrigation building need to be investigated. The article in this article assesses whether operations, maintenance and community involvement and outcomes in the form of economic benefits have a significant impact on the reliability of buildings. As a study site in Haliwen Irrigation in Atambua NTT.

Small dam reservoir(basin) is one of the infrastructures of water resources that will cover the water needs for various purposes during the dry season, by storing rainwater that falls to the earth and is being built in the basin area [8]. Irrigation basins are used for irrigation of agricultural land (rice fields and fields) and drinking water. The need for irrigation water in semi-arid areas is generally very high during the dry season. In addition, it depends on Damers for a certain period of time, depending on the nature of the plant and its growing season [9].

Irrigated irrigation structures are generally the same as dams in terms of both the dimensions and the capacity of the reservoir. Therefore, the structure of an irrigation reservoir generally consists of a dam body,

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a reservoir, an overflow, a supporting building and a water channel to the agricultural land. In the planning analysis, therefore, the principles of dam planning for the planning of irrigation basins were adopted. The general criteria that must be met are that the building must be stable in any situation or condition. High safety must be able to overcome the occurrence of runoff; Overflow capacity must also be able to drain; Seepage should not be excessive; If necessary, a cliff reinforcement around the structure of the dam [10] is required.

Therefore, structural stability in embedding is very important for it to function properly and to continue to ensure safety. Thanks to a stable structure, the building can be used reliably. The reliability of this building is one of the prerequisites for ensuring the sustainability of the irrigation system.

The operational aspects of the small dam reservoir building consist of two categories, namely the operation of the main building and the outbuildings. The main building consists of water extraction, drainage of buildings, dams, overflow gutters, wings in the upstream and downstream buildings and canals, while the outbuildings include the tapping of buildings and the water at irrigation canals and the dam support equipment [11]. While the maintenance aspects generally consist of routine maintenance and periodic maintenance including rehabilitation abilitation[12]

In addition to aspects of operation and maintenance, Community involvement plays an important role in the sustainability of irrigation systems. Participation by the Community can be channeled through participation in operational and maintenance activities and by participation in groups of Damers [13]. Community involvement also affects agricultural products and demonstrates the value of the benefits of embedding them. The value of this benefit can be determined from the results of the agricultural production and the sales value of the commodity so that the value of the actual benefit can be determined from the use of a reservoir.

II. METHODOLOGY

This study was conducted in the Haliwen irrigation area in Atambua, where the source of the water is from the embung Haliwen.This study is intended to examine the factors that influence the reliability of Small Dam Reservoir structures. These factors are identified first based on theoretical studies and previous studies. The factors to be examined are Operation, Maintenance, Community Participation, Benefits and Reliability Factors of small damreservior structure. The analysis carried out is to see the inter-factor linkages in looking at the possibility of sustainability of the irrigation system in terms of the reliability aspects of the structure.

The analysis used was multivariate analysis using structural equation modeling (SEM). For this reason, the factors of operation, maintenance, participation, benefit value and structural reliability are used as variables and then the indicators of each variable will be determined, thus fulfilling the criteria for latent variables in SEM. A complete description of the variables and indicators and their types can be seen in Table 1.

Table 1. Variable dan Indicator

Code	Variable	Indicator	Type of Indicator
X_1	Operation	Main Building Operations (X_{11})	Formative
		Auxiliary building operations (X_{12})	
X_2	Maintenance	Routine Maintenance (X_{21})	Formative
		Periodic Maintenance (X_{22})	
Y_1	Community Participation	Participation in Operation (Y_{11})	Reflective
		Participation in Maintenance (Y_{12})	
		Engagement in P3AI (Y_{13})	
Y_2	Benefit Value	Agricultural produce (Y_{21})	Reflective
		Commodity Selling Value (Y_{22})	
Y_3	Reliability of Building	Embankment (Y_{31})	Formative
		Reservoir (Y_{32})	
		Spillway (Y_{33})	
		Auxiliary Building (Y_{34})	
		Distribution network (Channel) (Y_{35})	

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Based on Table 1 and Figure 1, it can be used to solve structural equations using the SEM approach with WarpPLS. The main requirements in SEM analysis with WarpPLS are involving many variables, are latent, multi-relationship, tiered (not recrusive) models and there are relevant and formative indicators.Berdasarkan pada Tabel 1 dan Gambar 1 maka dapat digunakan penyelesaian persamaan struktural menggunakan pendekatan SEM dengan WarpPLS. Syarat utama dalam analisis SEM dengan WarpPLS adalah melibatkan banyak variabel, bersifat laten, multihubungan, model berjenjang (tidak rekrusif) dan terdapat indikator relektif dan formatif.

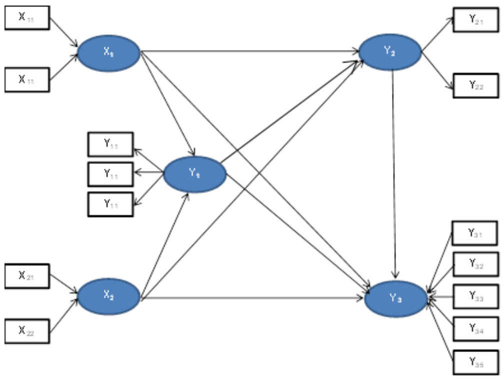

Figure 1. Model Persamaan Struktural

The model equation above can then be written in the form of a system of equations as follows:

$$Y_1 = \beta_{01} + \beta_1 X_1 + \beta_2 X_2 + \varepsilon_1 \quad (1)$$
$$Y_2 = \beta_{02} + \beta_2 X_1 + \beta_3 X_2 + \beta_4 Y_1 + \varepsilon_2 \quad (2)$$
$$Y_3 = \beta_{03} + \beta_3 X_1 + \beta_4 X_2 + \beta_5 Y_1 + \beta_6 Y_2 + \varepsilon_3 \quad (3)$$

The assessment of each varaible using a Likert Scale from 1 - 5 which shows the level of influence from very no effect to be very influential. In this study scale 1 states strongly disagree with a statement - up to 5 states strongly agree to a statement. The assessment was carried out by respondents consisting of elements of the water user community, related institutions and observers of irrigation problems (NGOs and academics) who had concerns about irrigation issues.

The test carried out is a test of validity, reliability and hypothesis testing. The validity is measured from the value of the loading factor (factor load)> 0.3 and ρ value <0.01 which indicates the significance. While reliability measured from the composite reliability coefficients was higher than 0.7 and Cronbach's aplha coefficients> 0.6. Furthermore, hypothesis testing was carried out using the t test as found in the WarpPLS analysis, using the resampling method and carried out by t-test. Determination of decisions on influential variables is based on the provision that if 10% and the value of ρ value <0.10 (alpha 10%) then it can be said to be weakly significant. Furthermore, if the value of ρ value <0.05 (alpha 5%) then the variable is significant and if ρ value <0.01 (alpha 1%) then varaibel is declared highly significant [14].

III. RESULT AND DISCUSSION

Haliwen small dam reservoir is a mainstay for the people of Belu Regency, especially in Sirani Village. The reservoir was built with the aim of irrigating agricultural land belonging to the community of Sirani Village and its surroundings. The Haliwen embankment has the same type, namely the weir type with a dike from the ground which is reinforced with rip rap, and an overflow type in the form of ogee. Haliwen reservoir is used to irrigate 300 Ha of agricultural land and for the clean water needs of the surrounding community. Capacity of Embung Haliwen is 1.860.000 m^3 and the total area of embung Haliwen is 28 Ha [15]

Visually, It looks good and can still function. There is no seepage in the dam body which can endanger the structural stability. In the pool, there are common problems in each reservoir, namely sedimentation.

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The handling of sedimentation is not carried out periodically so that it looks very dominant especially in the upstream upstream area and around the inlet.

The water distribution network in the form of a channel on both small dam reservoirs also functions well and is capable of flowing water to plots of rice fields and fields. However, for drinking water purposes, it is constrained by costs for operations.

Furthermore, the implementation of the main building operations is carried out by Damer groups in each small dam reservoir location. Damer groups carry out operations assisted and monitored by the local Public Works Agency. Implementation of operations includes building operations, among others, extracting water from small dam reservoir, water treatment and water distribution systems, especially during the dry season. The most important operational planning is monitoring water availability and formulating a system of cropping patterns.

From the analysis of the storage capacity of haliwen irrigation reservoirs for one year, the number of reservoirs according to the calculation results using the F.J Mock method was 228.031,922 M^3. Based on this capacity, then the system of cropping patterns is planned for the system as in Table 2.

Table 2.Cropping Patterns

NO	Cropping PatternsAlternatives	Planting Period	Total Availability	Total Needs
1	Rice-Rice-Corn	17-Des	228.031,922 m^3	27.656,876 m^3
2	Rice-Rice-Corn	28-Feb	228.031,922 m^3	27.274,861 m^3
3	Rice-Rice-Corn	20-Des	228.031,922 m^3	13.403,126 m^3

Based on the amount of irrigation water needs with the 3 alternative cropping patterns planned, the alternative type III cropping pattern is Rice - Rice - Corn (starting planting 20 December) with the amount of water demand is 13,403,126 M^3 which has been recommended for use in conducting Daming.

While related to maintenance programs are generally in the form of routine maintenance activities. Routine maintenance activities that have been carried out include cleaning of disturbing plants, giving lubricants to sluices, cleaning channels and repairing non-structural components.

SEM Analysis

In analyzing using SEM, it is necessary to test the validity and reliability of the tested variables. The WarpPLS approach requires convergent validity with a factor loading value> 0.5 and discriminant validity measured from the loading value of cross loading. Table 3 shows the value of the factor load for all variables then stated to meet convergent validity and also shows the value of loading> cross loading. For example $X_{1.1}$ loading variable 0.6> cross loading (0.007, -0.058, 0.07, -0.019), then fulfills convergent validity.

Table3. Combined loadings dan cross loadings

	Operation	Maintenance	Participation	Benefit	Reliability
$X_{1.1}$	**0.60**	0.007	-0.058	0.070	-0.019
$X_{1.2}$	**0.60**	-0.007	0.058	-0.070	0.019
$X_{2.1}$	-0.057	**0.55**	0.096	0.076	-0.162
$X_{2.2}$	0.057	**0.55**	-0.096	-0.076	0,11

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$Y_{1.1}$	-0.024	0.035	**0.58**	0.057	-0.085
$Y_{1.2}$	0.030	0.039	**0.58**	-0.052	-0.065
$Y_{1.3}$	-0.006	-0.081	**0.53**	-0.006	0,11
$Y_{2.1}$	-0.016	-0.002	-0.043	**0.62**	-0.019
$Y_{2.2}$	0.016	0.002	0.043	**0.62**	0.019
$Y_{3.1}$	-0.007	0.050	-0.001	-0.070	**0.55**
$Y_{3.2}$	0,10	0.066	-0.113	-0.107	**0.55**
$Y_{3.3}$	0.052	0.072	0.043	-0.248	**0.51**
$Y_{3.4}$	-0.026	-0.067	0.025	-0.057	**0.55**
$Y_{3.5}$	-0.214	-0.163	0.066	0,46	**0.59**

Furthermore, the reliability test is stated in the Composite Reliability and Cronbach's alpha values. Variables are declared reliable if the reliability composite coefficient is> 0.7 and alpha cronbach's coefficient> 0.6.

Table 4. Composite Reliability dan Cronbach's alpha

No	Variabel	Composite reliability coefficients	Cronbach's alpha coefficients
1	Operation	0.79	0.65
2	Maintenance	0.74	0.69
3	Community Participation	0.79	0.71
4	Benefit Vakue	0.82	0.72
5	Reliability	0.80	0.75

Table 4 shows that all variables have met the requirements of composite reliability and cronbach's alpha. In the Operation variable, the composite reliability coefficient is 0.79> 0., 7 (conditions) and the cronbach's alpha coefficient is 0.65> 0.6, so it meets the reliability requirements. Likewise, the variables of maintenance, community participation, value of benefits and reliability of buildings, all variables meet the element of reliability.

To see the relationship between factor loadings and the average value of each variable, it can be seen in the variable profile shown in Figure 2.

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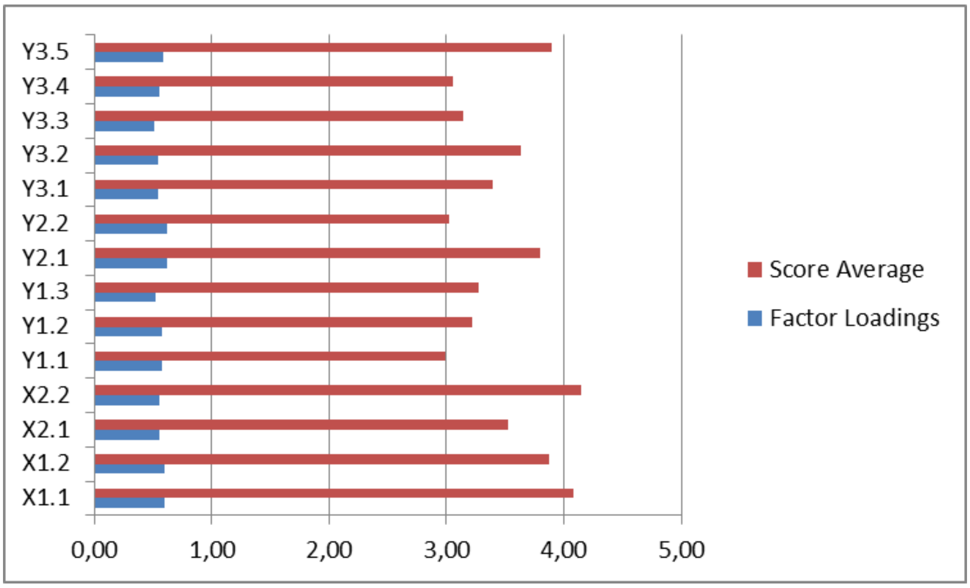

Figure 2. Variable Profile

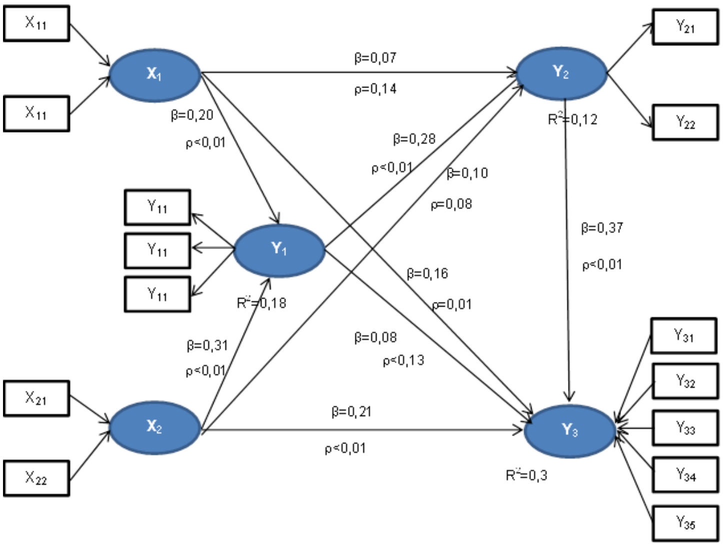

Figure 3. SEM Analysis Result

Figure 3 shows the relationship between variables which shows the level of influence indicated by the significance level of each variable in the model. The results of the analysis indicate that the small dam reservoir operating variable (X_1) has a significant effect on the reliability of small dam reservoir buildings where the value of $\rho = 0.01$. Whereas from the analysis results on reservoir maintenance variables it is known that the value of $\rho<0.01$ means that it has a very significant influence or relationship on the reliability of the building. Likewise the variable Value of benefits has a very significant relationship to the reliability of small dam reservoir buildings. Whereas the variable of community participation does not significantly influence the reliability of small dam reservoir buildings.

Furthermore, observing the pattern of relationships between variables in the model shows that the relationship between the variables of operation and maintenance of small dam reservoir with community participation is very significant where $\rho<0.01$It was also found that there was a strong relationship between community participation variables and the value of embung benefits, but the operation and maintenance did not significantly affect the value of benefits.

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IV. DISCUSSION

Assessment of the variables in this study shows how a performance of irrigation management in Haliwen. From the results of the assessment it was found that the feasibility of the operation of the main small dam reservoir building and maintenance of the small dam reservoir auxiliary building had the highest average score of 4.10 which can be said that the two variables were well and consistently implemented. While the lowest average score (<3.5) is in the community participation in operation and maintenance and involvement in P3AI; commodity selling value variable; and dam bodies, spillways and auxiliary buildings. This shows that the varaibel are still not managed or handled properly. Community participation is still one of the determinants of success in irrigation management to ensure sustainability [13].

In the variable selling value of this commodity in accordance with the data on the amount of agricultural commodities, especially only rice, then corn (see Table 2) while other agricultural commodities have not been cultivated. While the reliability of buildings seen from the stability of small dam reservoir structures according to respondents is still lacking. This assessment is indeed slightly different from the findings in the field of the dam body where the results of the investigation are still in a stable state. Structurally, the spillway still looks good, but there is a fairly thick sedimentation around the spillway building which affects the spillway performance. Likewise for auxiliary buildings, there is some damage to the channel walls, sluice gates, but it can still function and can deliver water properly.

Overall in terms of factor loadings, where the average> 0.5 indicates that all variables studied are important variables in ensuring the sustainability of an irrigation system in small dam reservoir Haliwen. This finding is in line with the intention of irrigation management to ensure the implementation of a good, sustainable irrigation system that benefits the community [2][12]. Theoretically operation and maintenance activities are the key to the success of an irrigation system and greatly affect the outcome of a Daming business that benefits the community. This must be supported by adequate community participation [16][17].

V. CONCLUSION

From the results of the analysis it is known the level of influence of each factor on the building constraints and the influence of factors in the model. In general, the influence of various factors examined in this study is very significant towards the reliability of the Small Dam Reservoir building except the aspect of community participation. However, the participation of the community has a significant effect on the results in the form of the benefits of small dam reservoir. This means that it shows an indirect influence on the reliability of embung buildings and the variable value of benefits is considered as a mediating variable and to obtain the optimal value of benefits operation and maintenance must involve community participation.

For this reason, in managing irrigation small dam it is very important to pay attention to these various factors. The plan for managing the Haliwen irrigation reservoir needs to consider various factors in this study.

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